Table of Contents

Power Supply

Power Supply

Model: All

Production: All

OBJECTIVES

After completion of this module you will be able to:

- Understand overall voltage supply layout
- Locate voltage supply components
- Locate fuse boxes
- Understand IBS operation
- Understand BST operation
- Describe terminal control in BMW vehicles
- Diagnose voltage supply faults

Introduction

The power supply is a combination of hardware and software that ensures the necessary power for all the vehicle systems.

Essentially it can be divided into two major functions:

- Energy management
- Power management

The energy management system ensures that sufficient starter motor current is always available and monitors the vehicle even when the engine is off. Energy management includes all the components in the vehicle that generate, store and consume energy. The data for the energy management is distributed across a number of control modules.

Power management is a subsystem of the energy management. The power management is run from the engine control module Digital Engine Electronics or Digital Diesel Electronics (DME or DDE). While the vehicle is being driven, the power management regulates the power output of the alternator as well as the battery charging.

For more information regarding Energy and Power management refer to the Power Management section of this training material.

The following are the basic components that make up the power supply system:

- Battery
- Alternator
- Battery cables
- Battery safety sensor
- Intelligent battery sensor
- Distribution box
- Junction Box Electronics
- Car Access System
- Digital Engine Electronics or Digital Diesel Electronics
- Multiple Restraint System
- Bit-serial data interface
- Relay box

Power Supply Components

Battery

General Battery Information

The battery is a chemical accumulator for the energy generated by the alternator. The battery is used in BMW vehicles as a starting battery which primarily serves to start and fire internal-combustion engines. The starter battery can delivery high currents for brief periods.

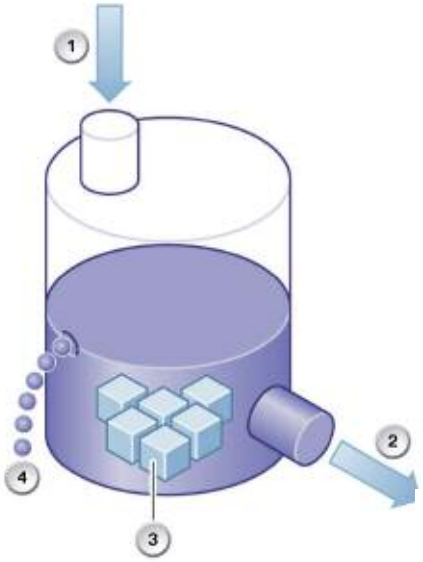
The battery must be able over a limited period of time (even when the engine is stopped) to supply important components of the vehicle electrical system with electrical energy. The battery must also have a damping effect in the event of voltage peaks in the electrical system in order to protect electronic components.

The battery consists of various cells connected in series. The cells are the smallest units in a battery and essentially comprise positive and negative electrodes, the separators and the parts required for assembly.

Battery Aging

All batteries are subject to natural wear and tear caused by the normal aging process. The battery depicted as a drum can only be completely filled when it is in perfect condition. The chemical processes in the battery consisting of the charging cycles with battery charging and discharging result in the formation of deposits in the battery which prevent the battery from maintaining full capacity.

Permanent self-discharge caused by stationary loads/consumers or increased energy consumption is another factor that dictates battery aging. Wear can be significantly increased by high or maximum demands (exhaustive discharge). Storage temperatures above 35 °C speed up the rate of battery self-discharge.



Index	Explanation
1	Battery Charge
2	Battery Discharge
3	Aging/deposits
4	Self-discharging

AGM Battery

Increasingly more powerful batteries are required because of the ever higher energy consumption of modern vehicle electrical systems. Since September 2002 all BMW vehicles have also been equipped with Valve Regulated Lead Acid (VRLA) batteries, better known as Absorbent Glass Mat (AGM) batteries.

Similarly sized AGM or VRLA batteries offer the following advantages:

- Longer service life.
- Increased starting reliability at low temperatures.
- Safe and reliable starting of engines with high power requirements.
- Because the sulphuric acid is completely retained in the glass-fiber fleece, no sulphuric acid can escape in the event of damage to the battery housing.

Note: These batteries can be recognized by their black housings and by the fact that they have no magic eye.

An AGM battery differs from its lead-calcium counterpart in the following features:

- Larger plates.
- 25 % higher power density.
- Separators made of glass-fiber fleece: this produces a cycle strength which is 3 times as high. This in turn improves cold-starting capability, current consumption and service life.
- Sealed housing with pressure relief valve (VRLA).
- Battery acid retained in the glass-fiber fleece.

Mode of Operation

The AGM battery differs from conventional batteries in its environmentally compatible and substance-maintaining performance during charging. When vehicle batteries are charged, the two gases oxygen and hydrogen are released.

- In a conventional, wet lead-calcium battery, the oxygen and hydrogen are dissipated to atmosphere.
- In an AGM battery, these two gases are converted back into water. The oxygen which is created during charging at the positive electrode passes through the permeable glass-fiber fleece to the negative electrode, where it reacts with the hydrogen ions in the electrolyte to form water.

In this way, no gases escape and electrolyte is not lost.

Special Features

In the event of an excessive build-up of gas, i.e. excessive pressure increase (20 to 200 mbar), the pressure relief valve blows off gas without allowing atmospheric oxygen to enter. Hence the designation VRLA.

Housing

AGM batteries must not be opened under any circumstances as the entry of atmospheric oxygen would cause the batteries to lose their chemical balance and render them inoperational.

Installation Locations

AGM batteries on account of their high spatial temperature differences must not be installed in the engine compartment. This would significantly reduce their service life.

Battery Replacement

A lead-calcium battery can always be replaced with an AGM battery provided the installation conditions conform to the specifications for AGM batteries. The use of an AGM battery does not require any changes to be made to the vehicle electrical system.

Alternator

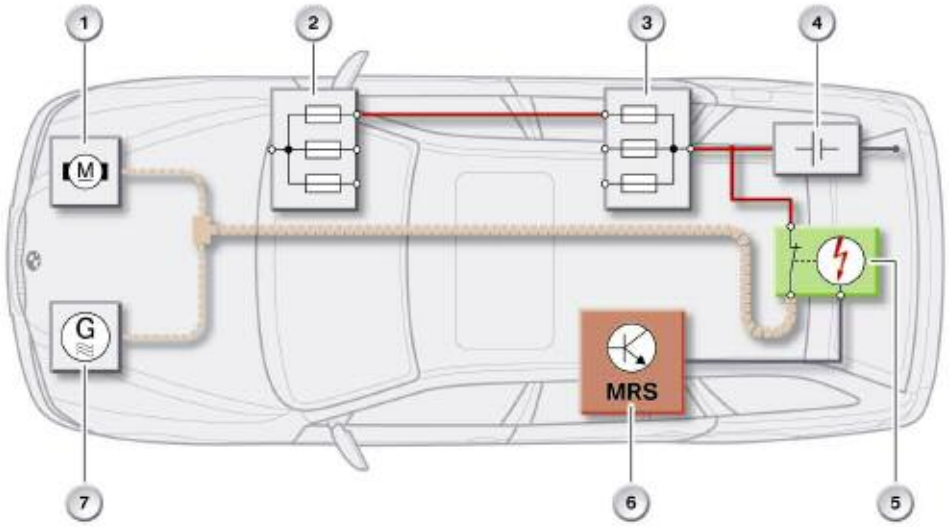
With the engine running, the alternator generates a variable charge voltage for battery charging. The variable charge voltage is influenced by the power management depending on the temperature and current.

Battery Cables

Depending on the vehicle the battery cables can be located in the vehicle interior or on the outside (under the floorpan). Depending on the model and equipment specification, the starter cable may also be equipped with a monitoring lead.

Some vehicles may be fitted with several battery cables. The starter cable is typically routed via the jump-start terminal point to the starter and the alternator.

Other battery cables are routed from rear to front power distribution box and to the electronics box in the engine compartment. These battery cables are designed in various cross-sections and materials. Copper and aluminum cables are currently used.



Index	Explanation	Index	Explanation
1	Starter	5	Safety Battery Terminal
2	Front power distribution box	6	Multiple Restraint System (ACSM)
3	Rear power distribution box	7	Alternator
4	Battery		

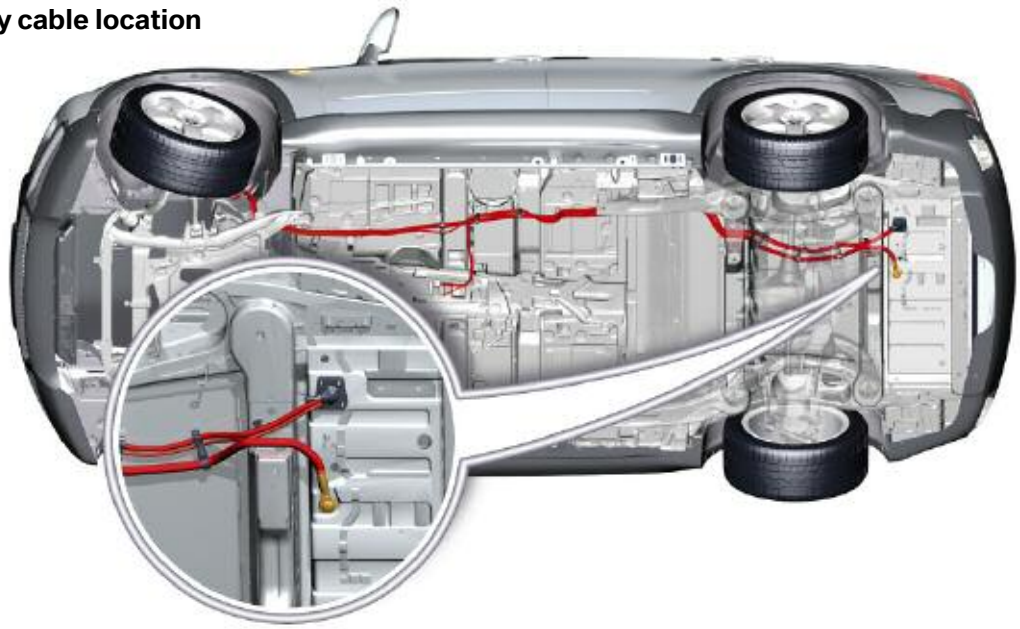
On the E70, for example, two main power leads run along the underbody from the battery box to the engine compartment. One of the main power leads is routed via the jump start terminal to the starter and to the alternator.

The other cable supplies the engine electronics with power. Depending on the model of vehicle, different cable cross sections are used.

The battery cable that connects to the front distribution box is installed in the vehicle interior. The transfer points (magnified view) for the two main power cables is located in the battery box. To avoid damage, the main power cables are installed in a protected area on the underbody.

One battery cable is installed in the vehicle interior. It runs to the front distribution box. The transfer points (magnified view) for the two main power cables is located in the battery box. To avoid damage, the main power cables are installed in a protected area on the underbody.

E70 battery cable location



Cable	Cross section	Material
Cable to starter and alternator on N62/N63 engine	110 mm^2	Aluminum
Cable to starter and alternator on N52/N55 engine	90 mm^2	Aluminum
Cable to front distribution box behind glove box	35 mm^2	Copper
Cable to the motor electronics	10 mm^2	Copper
Cable to electric fan 850 W	12 mm^2	Copper

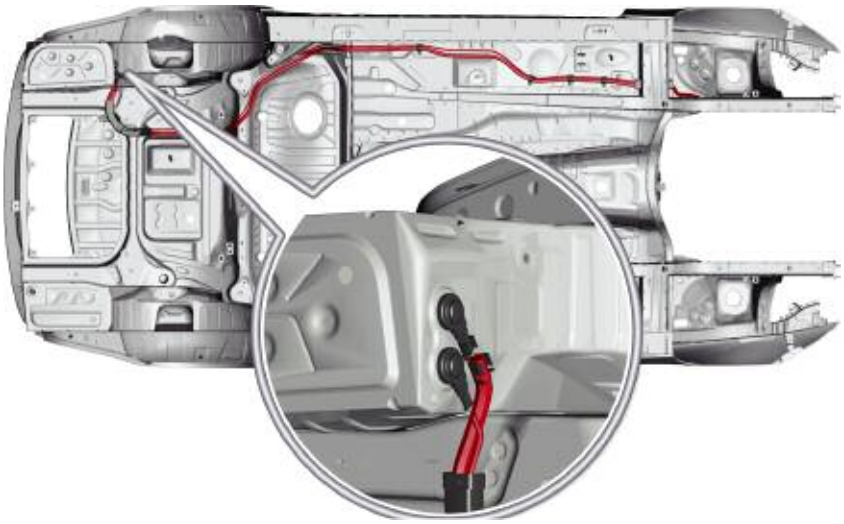
In the F01/F02, three main power lines on the underbody run from the distribution box at the battery to the engine compartment. One of the main power lines runs via the positive battery terminal to the starter motor and to the alternator.

The second line powers the engine electronics (and electric coolant pump).

The third line runs to the distribution box in the engine compartment. This distribution box supplies the electric fan with power. This line is safeguarded by the high-current fuse (100 A) in the distribution box at the battery.

In the E90 the starter, alternator, engine electronics and to the junction box are supplied by three main supply cables. These cables are run along the right side of the vehicle with the battery located the luggage compartment.

1. One main cable is routed on the interior of the vehicle along the right side, to the junction box located behind the glovebox.
2. Two additional main cables run from the B+ terminal underneath the vehicle to the engine compartment:
    - One cable goes to the jump start terminal in the engine compartment and then connects to the starter and alternator.
    - The second cable is used to supply power to the engine electronics (DME and Valvetronics).



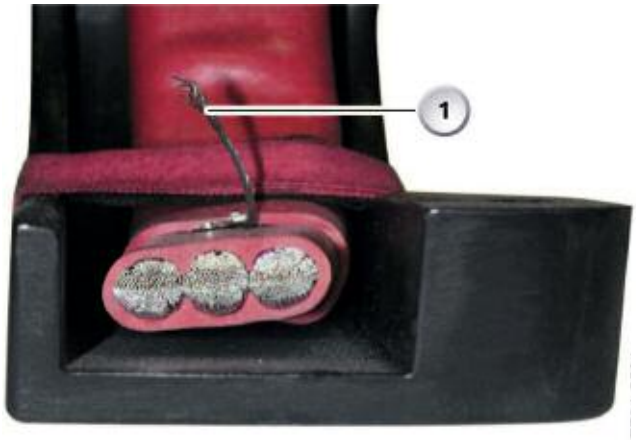
Within the battery box are two transfer points (as shown) for the two cables that run to the engine compartment.

The main power cables going to the engine compartment are installed/routed (as indicated) in a protected area underneath the body of the vehicle.

Aluminum Ribbon Cable

Since the launch of the E65/E66 vehicles an aluminum ribbon cable has been used as the battery cable in BMW vehicles. Depending on the vehicle model, the battery cable is equipped with a sensor lead.

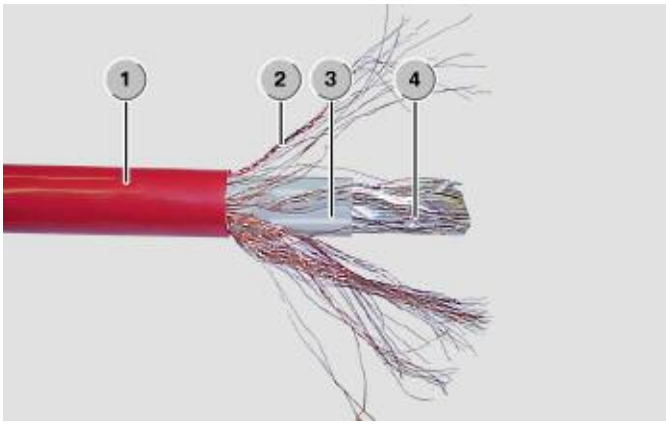
The battery cable is routed from the battery via the jump-start terminal point to the starter and the alternator.



Index	Explanation
1	Sensor lead

Battery Cable Monitoring

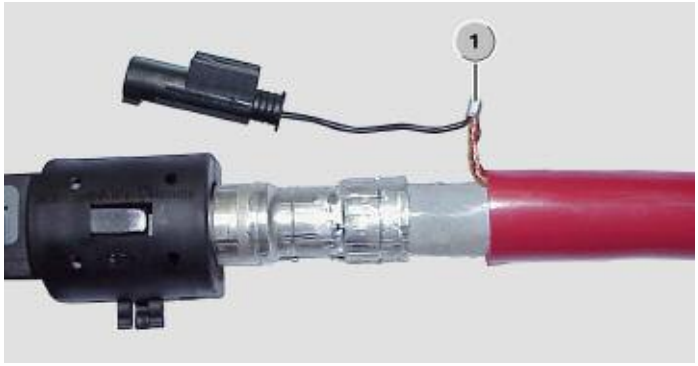
The battery cable is fitted with a low impedance metal mesh, which is insulated against the body and against the battery cable. This metal mesh is referred to as the monitoring shield.



Layout of Monitored Battery Cable

Index	Explanation
1	Outer insulation
2	Monitoring shield (copper braid)
3	Plastic insulation
4	Aluminum cable

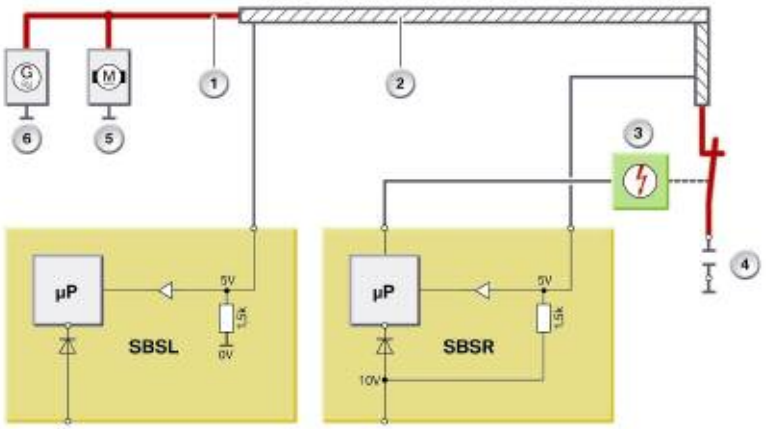
The monitoring facility of the battery cable comprises a copper shield which is wrapped round the plastic insulation of the aluminum cable.



Index	Explanation
1	Sensor lead

On the E60, for example, the battery cable is routed from the luggage compartment outside of the underbody of the vehicle into the engine compartment. If the cable is damaged in an accident or when driving over an obstacle (e.g. crash barrier), the battery cable is disconnected from the battery and the alternator is switched off. This prevents a short-circuit and the risk of sparks.

The monitoring cable in the engine compartment side is connected to the left B-pillar satellite and on the battery side (inside the luggage compartment) it is connected to the right B-pillar satellite. The battery cable is diagnosed by a special circuit between the SBSL and SBSR satellites.



Index	Explanation	Index	Explanation
1	Battery cable	5	Starter
2	Monitoring shield	6	Alternator
3	Safety Battery Terminal	SBSL	B-pillar satellite, left
4	Battery	SBSR	B-pillar satellite,right

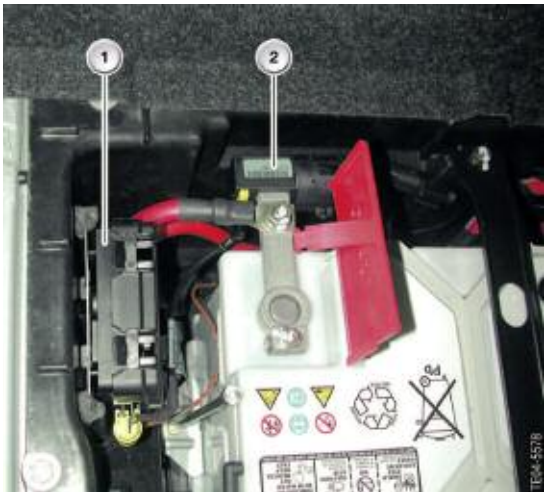
Note: Monitoring of the battery cable is described in detail in the E60 "Advanced Safety Electronics" training information found in TIS or ICP.

Battery Safety Terminal

The Battery Safety Terminal (BST) is used to reduce the risk of a short circuit to the B+ terminal of the battery in the event of an accident, as a result of a short circuit on the cable running from the B+ terminal of the battery to the Starter & Alternator (an unfused/unprotected circuit).

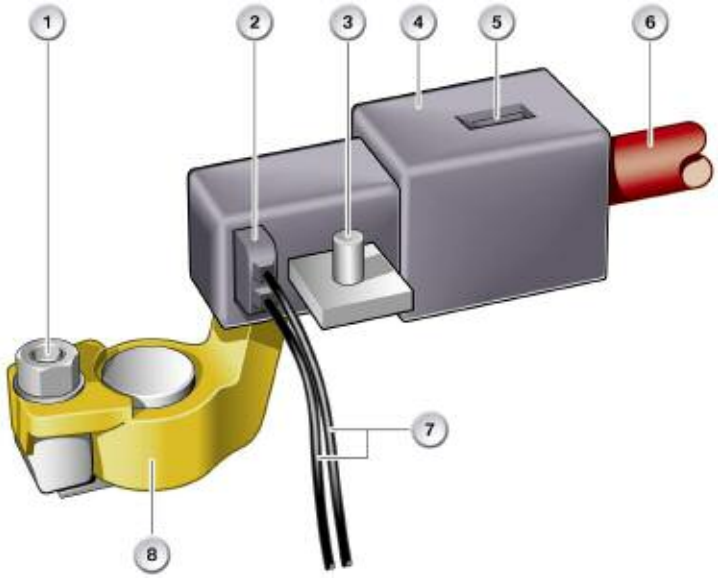
Depending on the severity of an accident incurred, the MRS control module will provide a signal to the BST which will disconnect the B+ cable going to the Starter & Alternator.

In the event that the BST is activated, power will continue to be supplied to the rear power distribution box (a fused/protected power distributor) to allow activation of all other vehicle systems (such as hazard lights, power locks, power windows, Engine Electronics etc.).



Index	Explanation
1	Heavy current fuse
2	Battery Safety Terminal

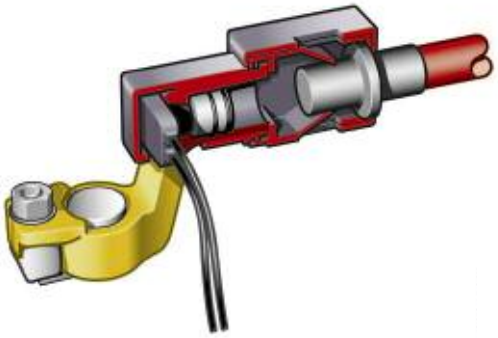
Battery Safety Terminal Components



Index	Explanation	Index	Explanation
1	Clamping screw	5	Locking pawl
2	Plug connection	6	Battery cable
3	Terminal B+	7	Control cable
4	Protective housing	8	Battery terminal

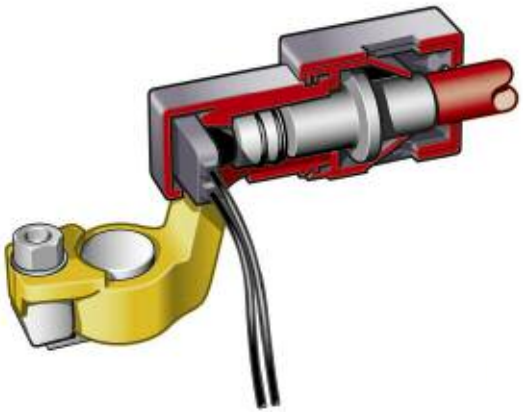
Cable Disconnection Sequence

The cable disconnection sequence is shown in the following illustrations.



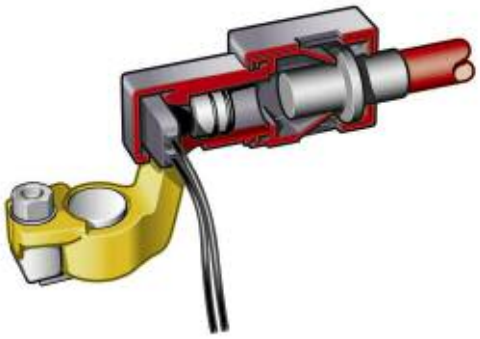
Initial state

1. Safety battery terminal initial state, time approx. 0.00 ms



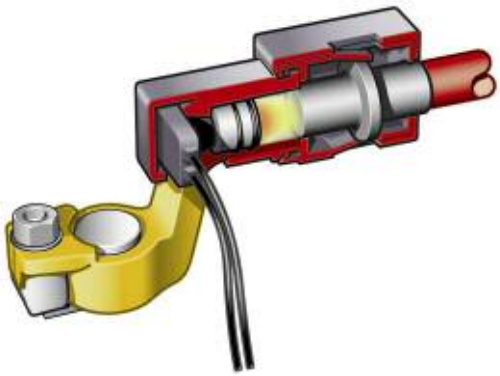
Disconnection operation

2. Disconnection operation is initiated,propellant charge is ignited by control unit,time approx. 0.22 ms



End of disconnection operation

3. Disconnection operation is concluded, time approx. 0.45 ms



Locking bar

4. Battery cable is received in the safety battery terminal, time approx. 3.00 ms

Note: The safety battery terminal may not be reused after the propellant charge has been triggered and must be replaced.

Because the battery cables are divided up in the rear distribution box, the rest of the vehicle electrical system remains operational when the safety battery terminal is triggered as long as none of the main fuses disconnect the circuit as the result of a short circuit. This ensures that all the important functions, such as e.g. hazard warning flashers, telephone, remain operational.

Intelligent Battery Sensor (IBS)

The intelligent battery sensor is an important component of the energy management in BMW vehicles with higher level equipment (e.g. navigation system).

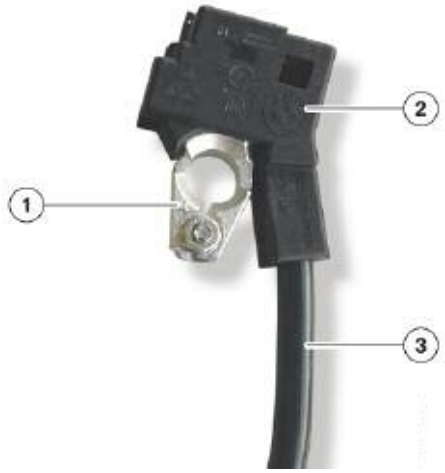
The term “intelligent” means that there is a microprocessor integrated in the IBS. This microprocessor calculates and analyses time-critical measured variables. The results are then forwarded to the higher-level control units (i.e. DME) via the LIN bus.

The IBS continually measures the following:

- **Battery terminal voltage**
- **Battery charge/discharge current**
- **Battery acid temperature**

This information is made available to the power management system in the DME/DDE. The IBS is located directly on the battery negative terminal and can thus be used for many BMW vehicle types.

The IBS can withstand temperatures of up to 105 °C and chemical loads and is therefore suitable for installation in both the luggage compartment and the engine compartment.



Index	Explanation
1	Negative battery terminal
2	Intelligent battery sensor
3	Negative battery cable

The intelligent battery sensor (IBS) is used to determine precisely the "state of charge" (SoC) and the "state of health" (SoH) of the battery.

The IBS consists of mechanical, hardware and software elements. The mechanical part consists of the battery terminal with ground cable for the negative terminal.

The functions of the mechanical section are:

- Providing electrical contact of the vehicle body with the negative terminal.
- Accommodating the sensor element for current measurement.
- Accommodating the hardware.
- Providing sufficient thermal contact between the temperature sensor of the hardware and the battery negative terminal.
- Providing protection for the sensitive electronic components.
- The battery terminal is the ground connection for the IBS.

The enhanced intelligent battery sensor as of F10 enables better detection of the battery condition by:

- Detection of defective battery cells.
- Calculation of the remaining battery capacity.

Each total discharge results in a loss of battery capacity:
The longer the battery remains completely discharged, the greater the loss of battery capacity.
The batteries installed at BMW can withstand several short total discharges or up to two long total discharges, however, when they are fully recharged with a constant charging voltage of 14.8 V after the total discharge.

For all models before F10, we should use the Midtronics tester, NOT a VAT40 or equivalent. For F10 and later vehicles, a battery test is built into the vehicle (through the IBS), and is accessed using ISTA.

Note: A battery may only be replaced on F10 when identified as faulty using ISTA (the test plan returns a Diagnostic Code for the replacement)

Note: For further information regarding the IBS (intelligent battery sensor) refer to the Energy Management with Micro-power Module in the Power Management section of this training material.

Power Distribution Boxes

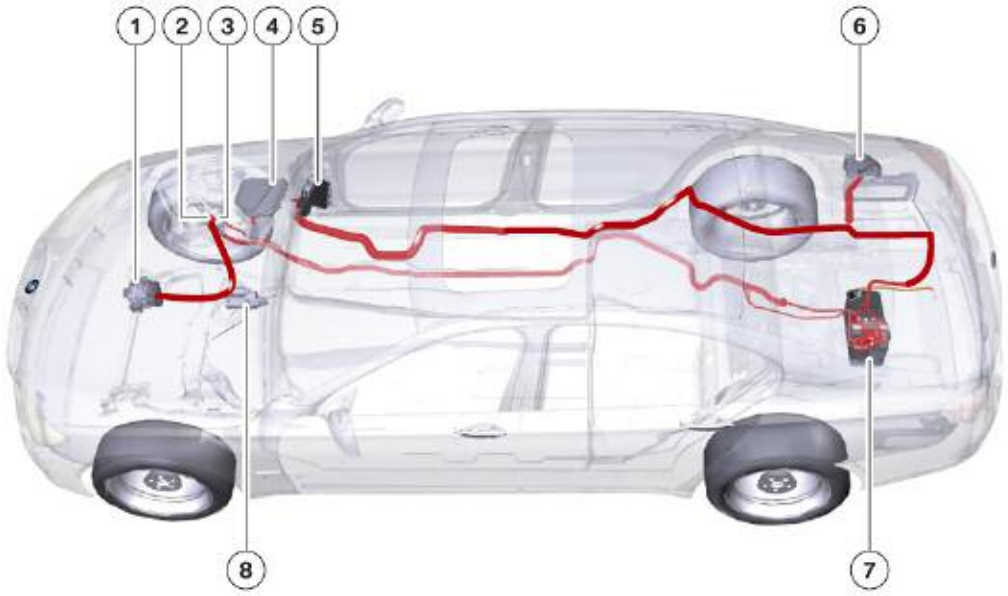
The fuses and relays are spread over different power distribution boxes in BMW vehicles. Some examples of possible installation locations are depicted in this chapter.

The distribution boxes can be incorporated in the luggage compartment, in the engine compartment and behind the glovebox. Even a combination of all three installation locations is possible, such as e.g. E65/E66.

In the E7x and F0x vehicles, there are two separate distribution boxes. The front distribution box is near the glove box and the rear distribution box is on the right-hand side of the luggage compartment.

The following graphic shows the arrangement of the most important components of the power supply system in the F0x.

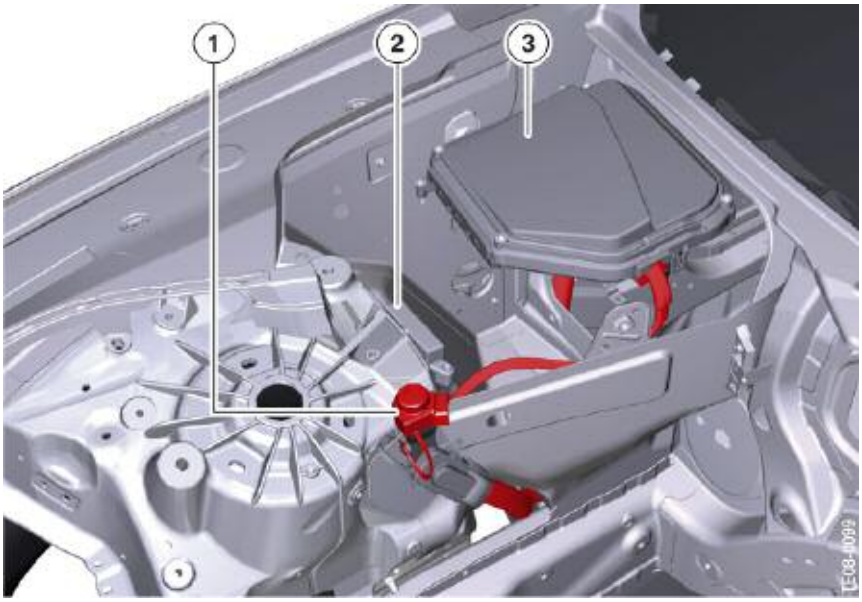
F01/02 power supply component locations



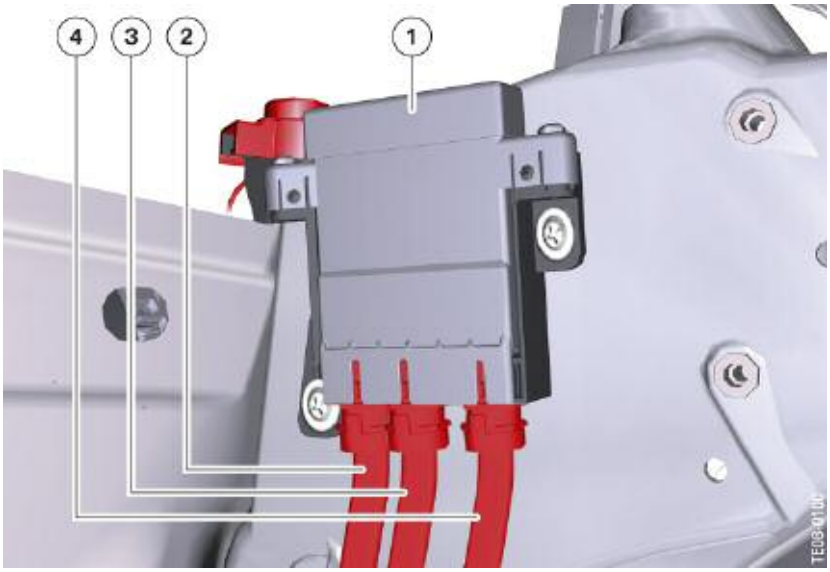
Index	Explanation
1	Alternator
2	Positive battery terminal
3	Power distribution box in engine compartment
4	Electronics box in the engine compartment
5	Front fuse carrier behind the glove compartment
6	Rear fuse carrier on the right-hand side of the luggage compartment
7	Battery
8	Starter

Power Distribution Box in Engine Compartment

There are no fuses in the engine compartment distribution box.



Index	Explanation	Index	Explanation
1	Positive battery terminal	3	Electronics Box
2	Power distribution box in engine compartment		



Index	Explanation	Index	Explanation
1	Power distribution box in engine compartment	3	Cable to electric fan
2	Cable from distribution box to battery	4	Not for US market

Junction Box

A battery cable leads from the power distribution box to the junction box. A junction box is installed in all vehicles as from the E90. The junction box is installed behind the glovebox beneath the instrument panel.

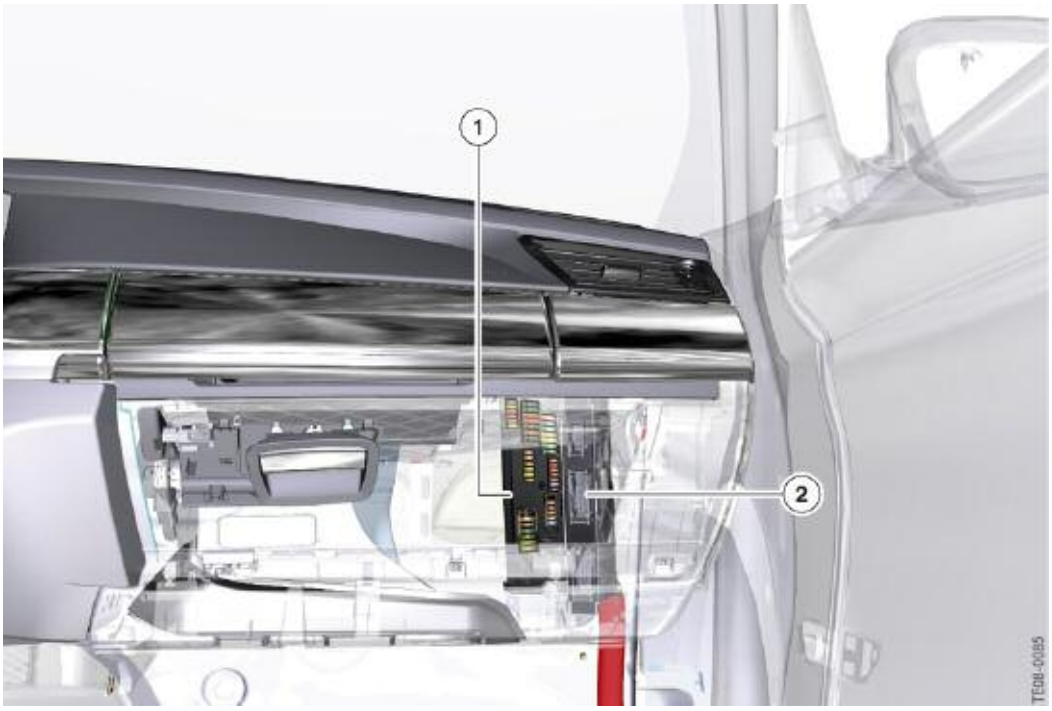
The junction box consists of two units:

- Junction box, electric part
- Junction box control unit

The junction box control unit is responsible for many functions such as the rear window defogger, power windows, outside mirrors, gateway function for the bus systems, etc.

Depending on the optional equipment installed in the vehicle, the electrical part of the junction box is equipped with various relays and fuses. In the bottom section of the junction box there is an opening which connects the junction box control unit to the electrical part of the junction box and the vehicle wiring harness.

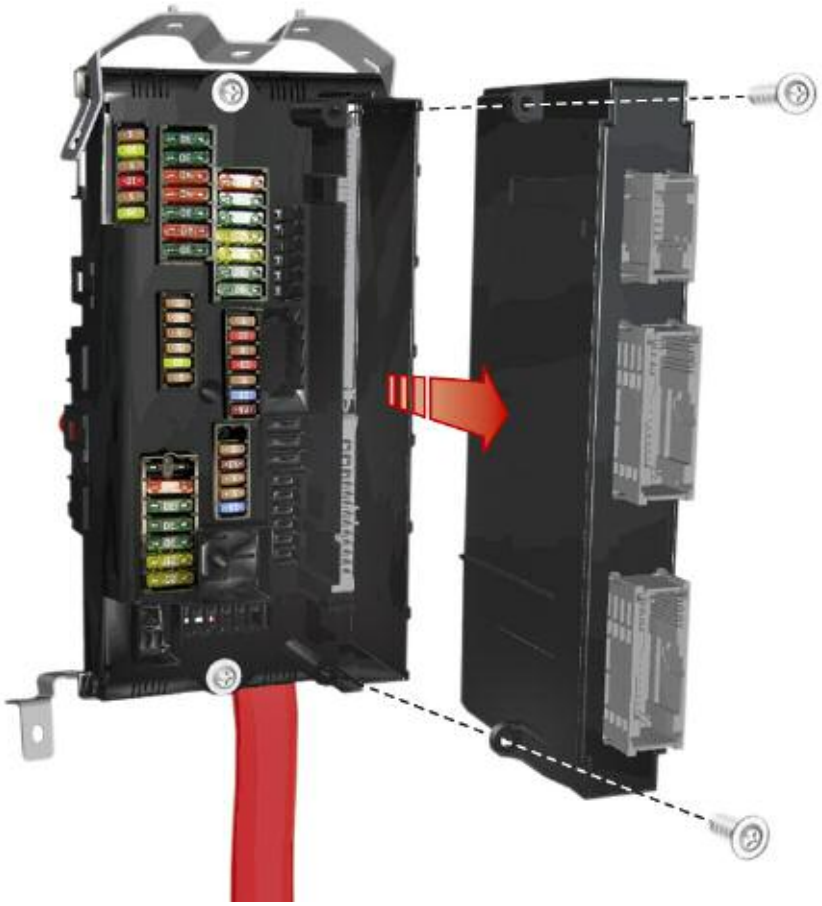
This graphic describes the F01/F02 front fuse carrier(1). In the right-hand part of the front fuse carrier, there is an opening through which the junction box electronics (2) are connected to the front fuse carrier.



Front Fuse Carrier and Junction Box Electronics

The connection between the front fuse carrier and the junction box electronics is established through the opening in the right-hand area of the fuse carrier. An internal plug connection provides the electrical connection between the two components.

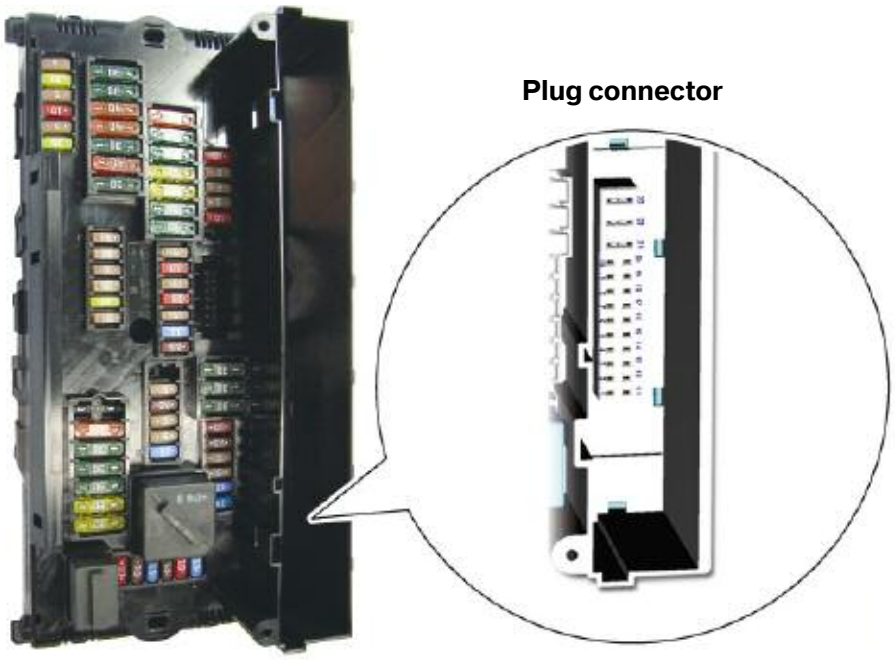
Junction box electronics and front fuse carrier in the F01/F02



When assembled, the two components form a single unit (junction box) consisting of the junction box electronics and the front fuse carrier.

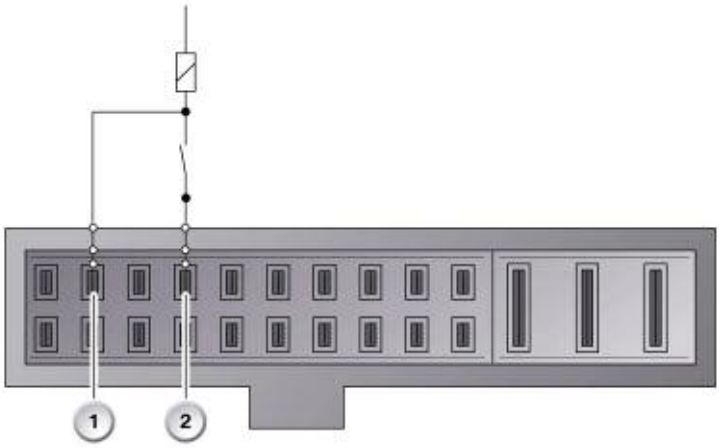
The fuse carrier and junction box electronics components must be replaced separately. In addition to the corresponding test modules in the diagnostics, diagnosis cables are also available with which electrical measurements can be made directly on the control-unit plugs and on the internal interface.

Internal Plug Connection



The internal plug connection is located on the right hand side, inside the opening for the junction box electronics.

Internal plug connection for the junction box electronics in the F01/F02



Index	Explanation	Index	Explanation
1	Monitoring connection	2	Actuation connection

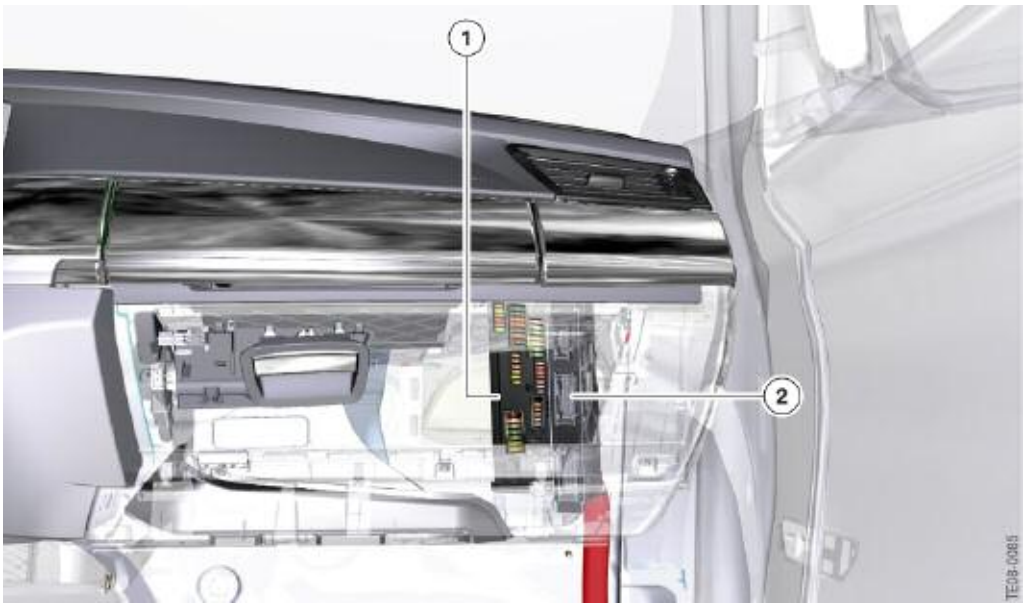
The internal plug connection is responsible for Relays in the front fuse carrier activating the relays in the front fuse carrier. In addition, the correct functioning of these relays is monitored by the Junction Box Electronics.

There are a few relays in the front fuse carrier. One of these is plugged in, the others are soldered to the circuit board.

Front Fuse Carrier

The front fuse carrier is located underneath the dashboard on the right-hand side. In order for a fuse to be replaced, the glove compartment must be opened.

In the right-hand part of the front fuse carrier (1), there is an opening through which the junction box electronics (2) are connected to the front fuse carrier.



Installation location of the front fuse carrier in the F01/F02

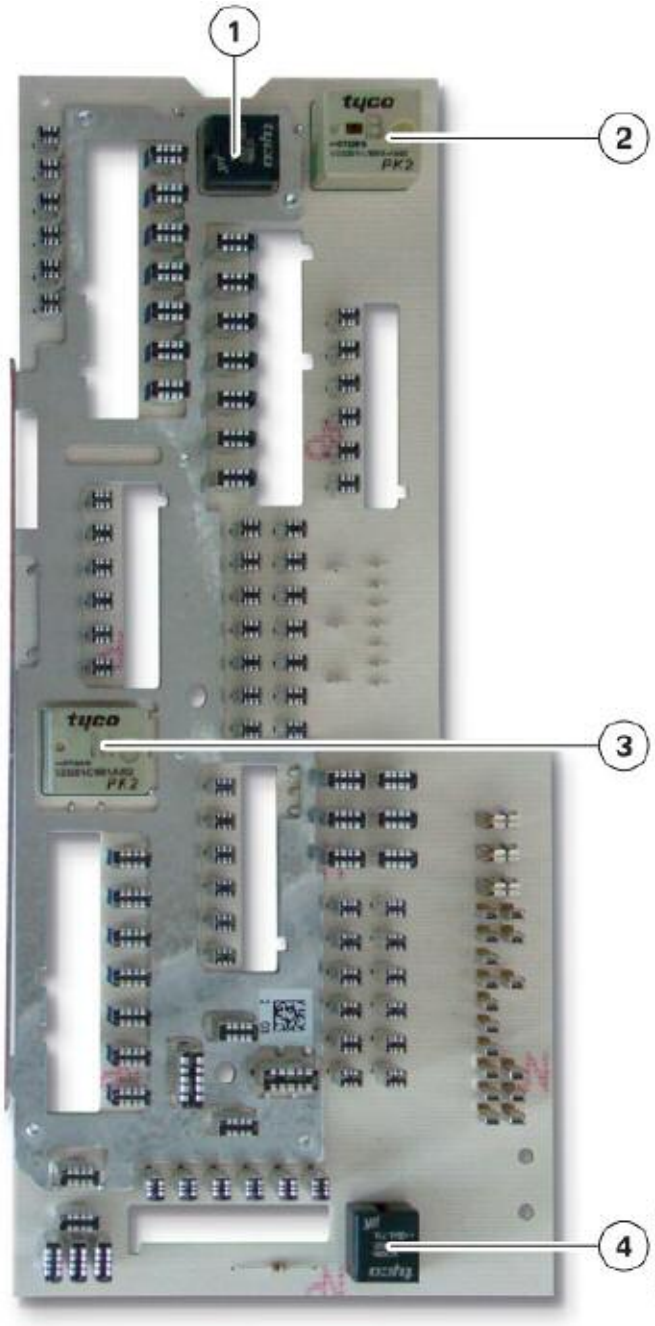
The printed circuit boards (PCB) on the inside of the junction box are different and correspond to the optional equipment installed in the vehicle. In the bottom section of the junction box there is an opening which connects the junction box control unit to the electrical part of the junction box and the vehicle wiring harness. The fuses are located in the middle area of the junction box. The various relays are located in the left and right areas.

Different soldered relays are used in the glovebox fuse carrier corresponding to the equipment in the vehicle and engine specification.

Soldered Relay

Various relays are soldered to the circuit board in the front fuse carrier. In the event of a fault, the fuse carrier must be replaced as a complete unit.

Internal view of the front fuse carrier, F01/F02



Index	Explanation	Index	Explanation
1	Relay, terminal 30F (bistable)	3	Relay, terminal 15N
2	Relay for the headlight cleaning system	4	Horn relay

Direct Contacting

On the distribution boxes, direct contacting to the fuses is carried out. The fuses are plugged into the plug connections on the circuit board with a connection. The other plug connections are directly connected to the connecting plugs on the wiring harness.

The advantages of this design modification are:

- Improved package space utilization.
- Improved heat dissipation.

Direct contacting of fuses in the F01/F02

Index	Explanation	Index	Explanation
1	Front fuse carrier housing	3	Wiring harness connector
2	Fuse		

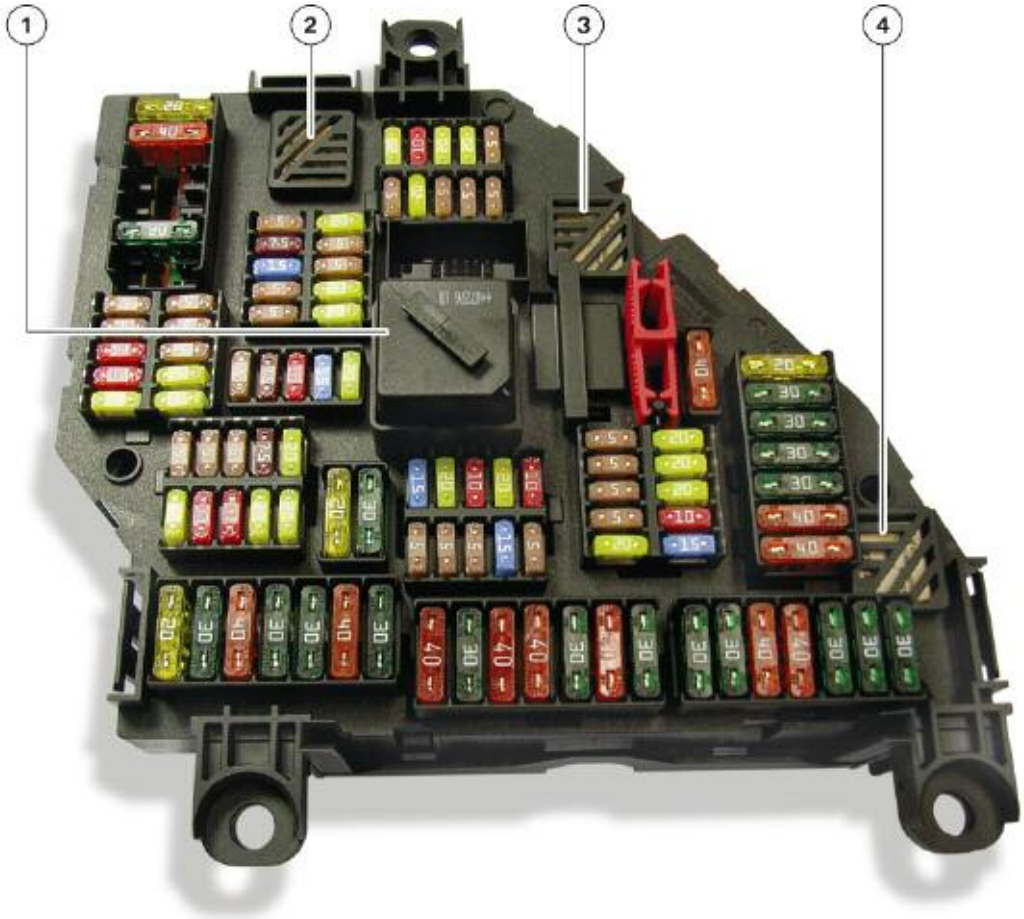
Particular care must be taken to ensure that the fuses are fitted firmly when unplugging and reconnecting the connectors for the wiring harness. The fuses must be braced when plugging in the wiring harness.

Rear Fuse Carrier in the Luggage Compartment

Due to the large number of consumers and control units in the F01/F02, an additional fuse carrier has been fitted in the luggage compartment.

As well as the fuses, a few relays are plugged in here or soldered to the circuit board. If one of the soldered relays is faulty, the rear distribution box must be replaced as a whole unit. The connection port of the battery cable is located on the rear of the fuse carrier.

External view of the rear fuse carrier in the F01/F02

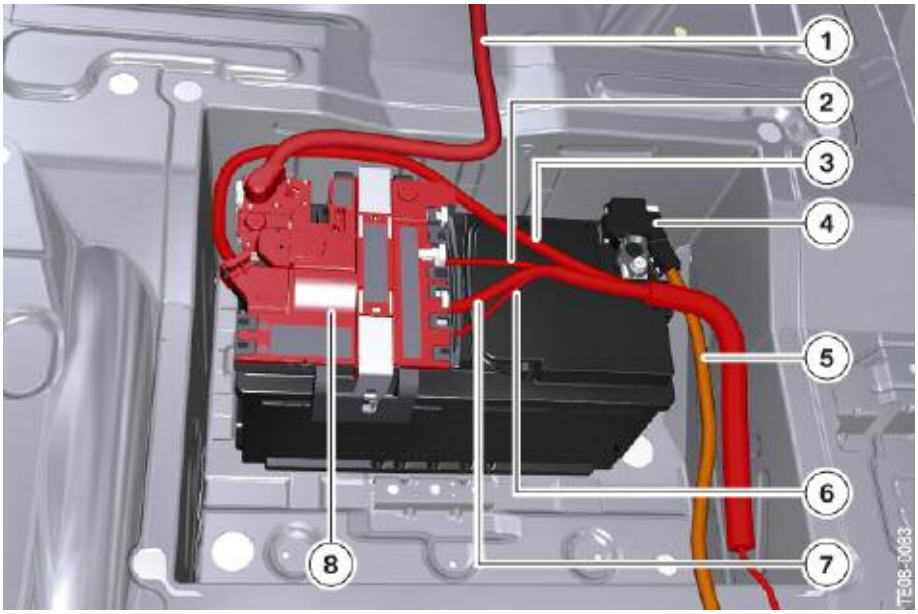


Index	Explanation	Index	Explanation
1	Relay terminal 30B (plugged in)	3	Relay terminal 15N (soldered)
2	Relay terminal 30F (soldered)	4	Relay for the heating element in the rear window (soldered)

Distribution Box on the Battery

In the F01/F02, the distribution box is located in the luggage compartment directly on top of the vehicle battery.

Installation location of the distribution box on the battery in the F01/F02



Index	Explanation	Index	Explanation
1	Battery cable to the starter and alternator 5	5	Negative battery cable
2	Cable to the rear fuse carrier on the right-hand side	6	Cable to the power distribution box in the engine compartment
3	Cable to the front fuse carrier	7	Cable to the electronics box in the engine compartment
4	Intelligent battery sensor IBS	8	Distribution box on the battery

The distribution box on the battery is secured on the vehicle battery by means of a metal tab. The metal tabs must be pressed downward and outward in order to release the distribution box.

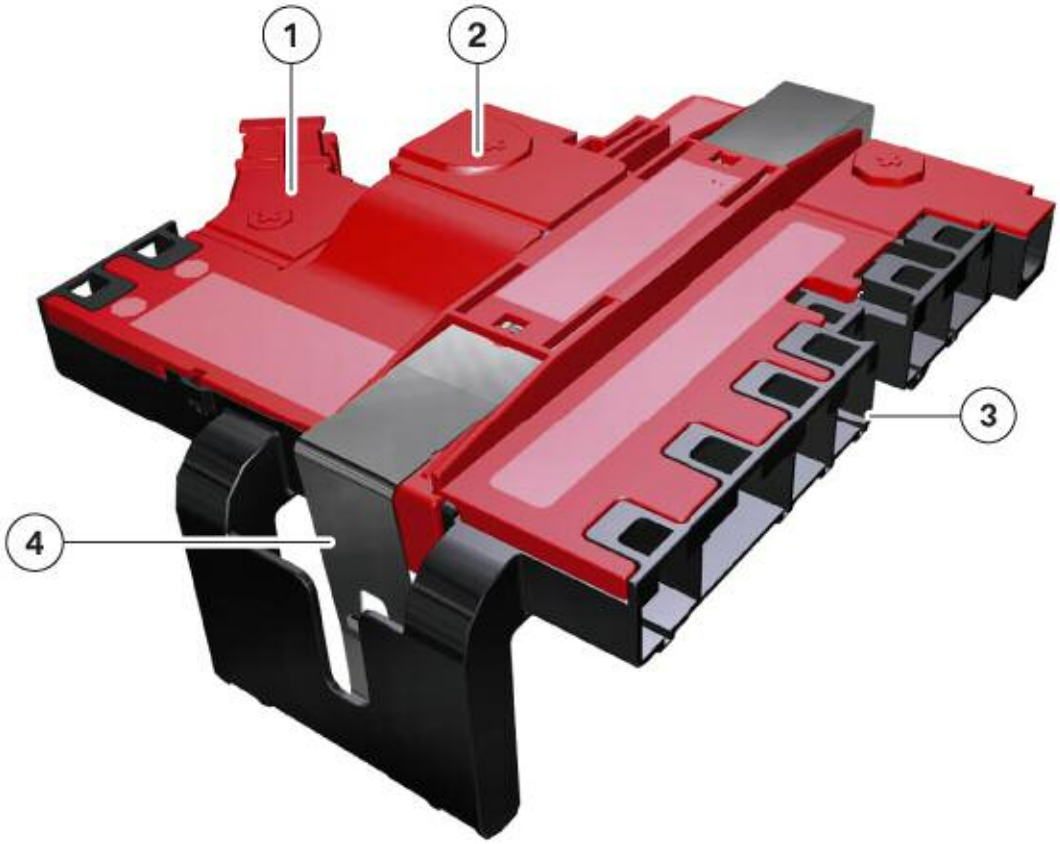
The distribution box on the battery is equipped with fuses for the following electric loads:

- Front fuse carrier (250 A)
- Rear fuse carrier (100 A)
- Engine compartment distribution box (100 A)
  - large electric fan (850 W or 1000 W)
- Electric coolant pump (100 A)
- Intelligent battery sensor IBS

The distribution box on the battery must always be replaced as a complete unit.
The fuses are integrated as a complete unit in the housing of the distribution box on the battery. The fuses differ in terms of their power rating. The distribution box additionally contains the power supply for the intelligent battery sensor IBS.

The connectors are color-coded and mechanically coded to avoid confusion.
These are high power connections, therefore always ensure correct contacting!

Distribution box on the battery in the F01/F02

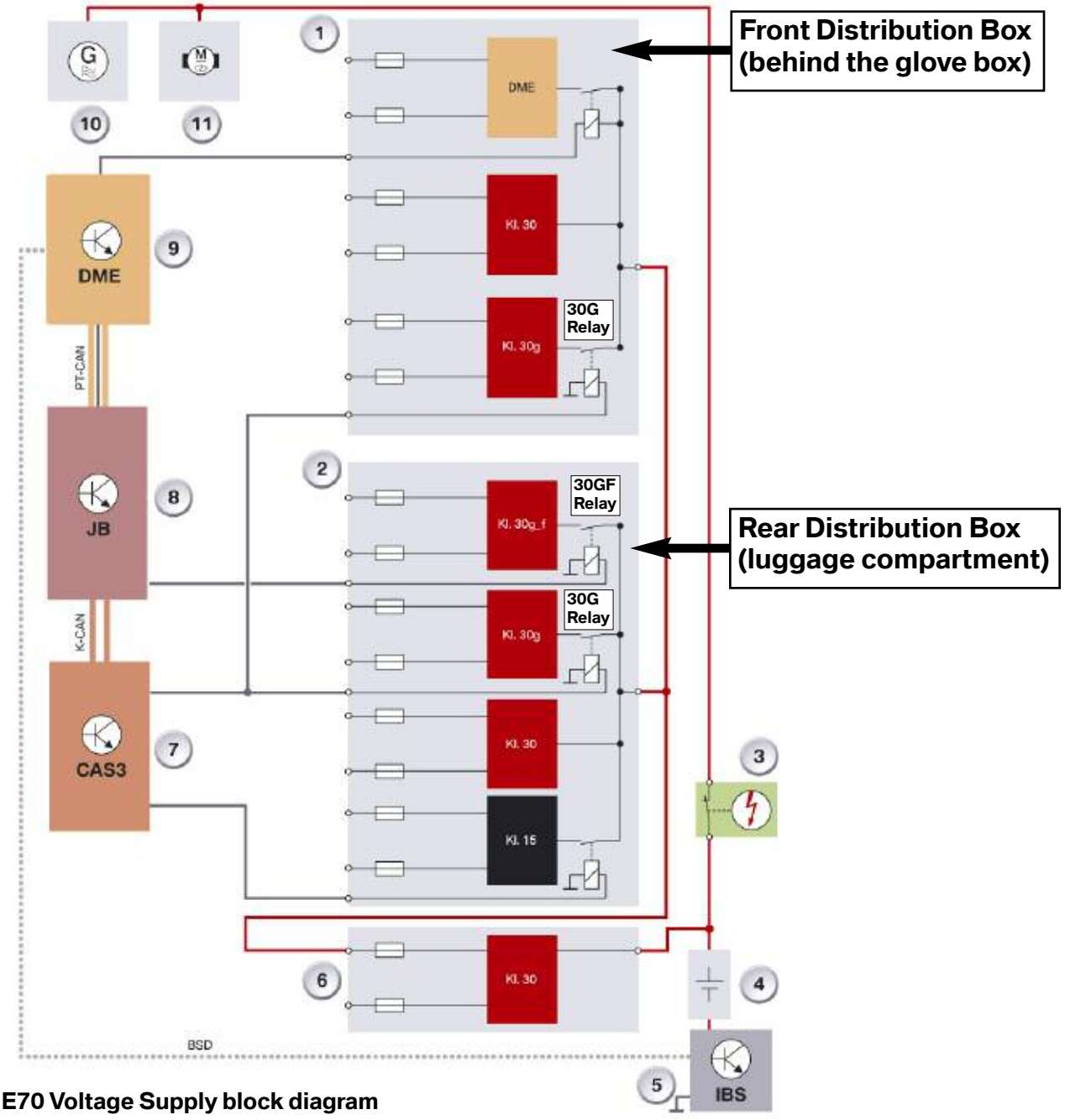


Index	Explanation	Index	Explanation
1	Connection for the battery cable to the front fuse carrier	3	High current consumer connections
2	Connection to battery terminal	4	Retaining clip

Note: When replacing or working on the distribution box, always make sure the plug connections and, above all, the screw connections are secured properly. Connection between battery terminal and distribution box 15 Nm.

Terminals

All electrical loads in the vehicle must be connected to ground on the one side and to the positive voltage on the other. In electrical engineering applications, a terminal provides a detachable connection or serves the purpose of connecting wires, cores and cables. In motor vehicles, the term terminal refers to connection points, at which control units and electronic components are supplied with current. There are various terminals with standardized designations. The most important terminals in the voltage supply system are described in more detail based on the following example.



E70 Voltage Supply block diagram

E70 Voltage Supply block diagram legend

Index	Explanation
1	Front distribution box, behind glove compartment
2	Rear distribution box, right hand side of luggage compartment
3	Safety battery terminal
4	Vehicle battery
5	Intelligent battery sensor (IBS)
6	Distribution box, on battery
7	Car Access System 3 (CAS 3)
8	Junction box control unit (JBE)
9	Digital Motor Electronic (DME)
10	Alternator
11	Starter
KL30	Continuous B+ (battery power)
KL30g_f	Switched positive (fault dependent)
KL30g	Switched positive, time dependent
KL15	Ignition ON
DME	DME main relay
BSD	Bit-serial data interface
K-CAN	Body CAN
PT-CAN	Powertrain CAN

Note: For more information regarding connections and terminals refer to the "Terminal Control" section of this training material.

Terminal 30
All electrical loads in a vehicle are permanently connected to ground via the negative terminal of the vehicle battery. Some of the electric loads in the vehicle are also permanently connected to the positive terminal of the vehicle battery. This current circuit is interrupted only by switches or relays.

The terminal in the vehicle's electrical system, at which battery voltage is permanently applied is referred to as terminal 30 (also known as B+ or continuous positive). With the battery installed and connected, electrical power is made available on this branch of the wiring harness when the ignition is turned off and the ignition key removed. Terminal 30 powers the control units and assemblies which must remain operative even when the vehicle is shut down or which only require electrical energy in order to maintain data. The switch for the hazard warning light system, for example, is powered via terminal 30.

Terminal R
A proportion of the electric loads is connected to the positive terminal of the battery only after inserting the ignition key in the ignition lock and turning it to the first notch position, thus applying the electric loads with current. In this case, the ignition lock acts as a switch. The terminal is designated terminal R.

Example: If connected via terminal 30 (continuous positive), a car radio can be operated even when the ignition key is removed. If, on the other hand, it is connected via terminal R, it can be operated only when terminal R is switched on. In addition to the radio, the control unit for the safety system (MRS, ACSM) also receives its voltage via this terminal.

Terminal 15
Terminal 15 (also switched positive, ignition positive) is activated when the ignition key is turned to the second notch position. Further control units and electrical components receive their voltage supply via terminal 15.

For example, the air conditioning system and parking aid (PDC) are switched on via terminal15. Terminal R and terminal 15 are controlled by the CAS control unit.

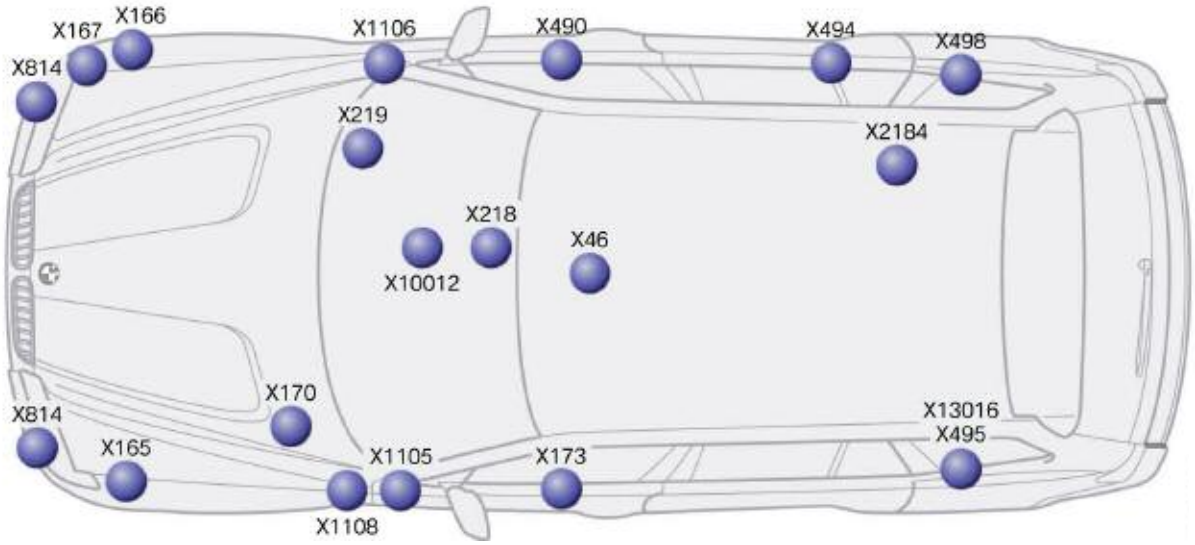
Terminal 31
Because every current consumer is incorporated in a circuit, it requires the necessary earth/ground connection in addition to the B+ power supply. The connection to the battery negative terminal is established via a separate ground lead and the body panel. This connection is also known as terminal 31 (ground).

Because the number of electrical systems and loads has increased, it would cause considerable problems to screw every ground connection directly to the body.

For this reason, BMW vehicles have central ground points with screwed-on strip connectors for accommodating as many ground leads as required.

Ground Points

Examples of distribution of ground points in a vehicle without GRAV



Ground points on E83 example

Index	Explanation	Index	Explanation
X814	Ground, up-front sensors	X495	Ground, rear left
X167	Ground, electric fan	X173	Ground, driver's seat
X166	Ground, right headlight	X1108	Ground, steering column
X1105	Ground, multiple restraint system	X170	Ground, DSC control unit
X490	Ground, front passenger seat	X165	Ground, left headlight
X494	Ground, rear right	X46	Ground, seat occupancy detection, seat-belt switch
X498	Ground, rear window	X218	Ground, center console switch center
X2184	Ground, transfer case	X10012	Ground, front power distribution box
X13016	Control units, rear right	X219	Ground, instrument panel

Examples of distribution of ground points in a vehicle with GRAV

Ground points on E60 example

Index	Explanation	Index	Explanation
1	X13796 Strip connector	11	X13797 Cable shoe, blower
2	X13795 Strip connector	12	X14054 Cable shoe, PTC
3	X13791 Strip connector	13	X13786 Strip connector
4	X13787 Strip connector	14	X13788 Strip connector
5	X13789 Strip connector	15	X13556 Cable shoe
6	X13785 Strip connector	16	X13790 Strip connector
7	X13783 Strip connector	17	X13794 Strip connector
8	Ground point GRAV	18	X13792 Strip connector
9	X13782 Strip connector	19	X6402 Cable shoe, battery
10	X13784 Strip connector		

Vehicles with Reduced-weight Aluminum Front End (GRAV)

The reduced-weight aluminum front end is connected to the steel body by way of a ground connection.

The ground point for jump-starting is located on the front left spring support. In the event of a jump start, there is a risk of high currents flowing through the punched connection, which causes the rivets to heat up and results in damage to the adhesive.

Ground connection on E60 with GRAV front end

Index	Explanation
1	Ground connection bracket of the reduced-weight aluminum front end (GRAV)

The weight-reduced aluminum front end (GRAV) ground connection also improves the vehicle's electromagnetic compatibility (EMC).

Aging connections between the front end and the remaining car body do not affect the EMC.

The contact resistances between the front end and the remaining car body are bridged by means of the ground bracket.